CLAIMS

1. A regenerative energy management system adapted for use with a compound vehicle comprising a prime mover including an engine connected to driven wheels via a drive train and a trailer including at least one independent wheel isolated from the drive train, the energy management system including:-

energy accumulation means operable selectively to store and release energy through controlled receipt and release of pressurised hydraulic fluid;

a positive displacement hydraulic pump/motor assembly in fluid communication with the energy accumulation means; and

a low-pressure hydraulic reservoir in fluid communication with the pump/motor assembly;

the pump/motor assembly having a drive shaft adapted for connection to at least an associated one of the independent wheels of the trailer;

the system being arranged such that in a braking mode the pump/motor assembly retards the associated wheel of the trailer by pumping hydraulic fluid into the accumulation means, in a driving mode the pump/motor assembly supplies supplementary power to the associated wheel of the trailer using pressurised hydraulic fluid from the accumulation means, and in a neutral mode the pump/motor assembly exerts no substantial driving or retarding influence on the associated trailer wheel;

the system thereby in use being adapted to supply regenerative drive and retardation to the trailer substantially independently of the prime mover.

2. A regenerative energy management system according to claim 1, wherein the hydraulic pump/motor assembly includes:-

a rotary cylinder block having a central axis and incorporating a generally circular array of cylinders disposed around the axis;

a corresponding plurality of pistons reciprocably disposed within the respective cylinders;

a drive plate disposed at one end of the cylinder block to effect sequentially staggered reciprocation of the pistons in response to rotation of the cylinder block;

a stationary valve plate disposed at an opposite end of the cylinder block, the valve plate having a valve face adapted for sliding rotational engagement with a complementary mating face formed on the cylinder block;

the valve plate further including at least one inlet port adapted for fluid communication with the low-pressure reservoir and at least one outlet port adapted for fluid communication with the accumulation means;

the ports being disposed such that in use, hydraulic fluid is progressively drawn into the cylinders in sequence through the inlet ports as the respective pistons are displaced away from the valve plate and subsequently expelled from the cylinders through the outlet ports as the pistons are progressively displaced toward the valve plate.

3. A regenerative energy management system according to claim 2, wherein the cylinders are disposed in generally parallel relationship around the axis.

4. A regenerative energy management system according to claim 2, wherein the cylinders are disposed in generally radial relationship around the axis.

5. A regenerative energy management system according to any one of claims 2 to 4, wherein the drive shaft extends coaxially through a complementary bore formed in the cylinder block, to effect rotation of the cylinder block about the central axis.

6. A regenerative energy management system according to claim 5, wherein the pump/motor assembly further includes a selectively releasable decoupling mechanism disposed effectively intermediate the drive shaft and the cylinder block.

7. A regenerative energy management system according to claim 6, wherein the decoupling mechanism is adapted in an engaged mode to connect the drive shaft to the cylinder block and in a disengaged mode to allow the drive shaft to rotate substantially independently of the cylinder block.

8. A regenerative energy management system according to claim 7, wherein the decoupling means include a clutch mechanism disposed coaxially around the drive shaft, to selectively transmit rotary drive between the drive shaft and the cylinder block.

9. A regenerative energy management system according to claim 2, wherein the drive plate takes the form of a stationary swash plate, which is inclined with respect to the central rotational axis of the cylinder block.

10. A regenerative energy management system according to claim 9, wherein floating ends of the pistons remote from the valve plate include followers adapted to slide over the swash plate as the cylinder block rotates.

11. A regenerative energy management system according to claim 10, wherein a hold-down plate is disposed to capture the floating ends of the pistons and retain the followers in sliding contact with the swash plate.

12. A regenerative energy management system according to any one of claims 9 to 11, wherein an angle of inclination of the swash plate is selectively adjustable, to provide variable flow rate characteristics.

13. A regenerative energy management system according to claim 12, wherein the swash plate is adapted to be selectively inclined in a positive or a negative sense, thereby enabling the assembly alternately to operate as a motor or a pump.

14. A regenerative energy management system according to claim 13, wherein the swash plate can also be oriented in an intermediate or neutral position, effectively normal to the central axis, such that rotation of the cylinder block causes no movement of the pistons, hence induces no net flow into or out of the cylinders through the ports, and therefore causes no substantial load on the system.

15. A regenerative energy management system according to claim 2, wherein the pump/motor assembly includes at least three external ports to permit ingress and egress of hydraulic fluid, with a first port communicating with an inlet of the hydraulic reservoir, a second port communicating with an outlet of the hydraulic reservoir, and a third port communicating with the accumulation means.

16. A regenerative energy management system according to claim 15, wherein a heat exchanger is disposed between the first port and the reservoir.

17. A regenerative energy management system according to any one of the preceding claims, wherein a plurality of the pumps is arranged axially along the drive shaft.

18. A regenerative energy management system according to any one of the preceding claims, further including a flow control circuit through which hydraulic fluid may be selectively directed, the control circuit being adapted to provide a controllable resistance enabling the pump/motor unit selectively to exert a retarding force on the drive shaft when the accumulators are fully charged.

19. A regenerative energy management system according to any one of the preceding claims, wherein the accumulation means include a gas/liquid accumulator

comprising a double-ended accumulation cylinder and a piston adapted to float sealingly within the cylinder.

20. A regenerative energy management system according to claim 19, wherein one side of the accumulation cylinder contains a compressible inert gas, and the other side of the cylinder is connected hydraulically to the pump/motor unit.

21. A regenerative energy management system according to claim 20, wherein the accumulator is adapted to store energy by pumping hydraulic fluid into one side of the cylinder, so as to compress the gas on the other side by displacement of the floating piston, and subsequently to release that energy by expulsion of hydraulic fluid as the compressed gas expands.

22. A regenerative energy management system according to claim 21, wherein the output shaft of the primary motor and the drive shaft of the pump/motor unit are integrally formed.

23. A regenerative energy management system according to any one of the preceding claims, wherein the pump/motor unit is mounted directly to a freewheeling axle supporting one or more of the associated non-driven wheels of the wagon, such that the axle and the drive shaft of the pump/motor unit are coupled for conjoined rotation.

24. A regenerative energy management system according to claim 23, wherein the axle and the output shaft are integrally formed.

25. A regenerative energy management system according to any one of the preceding claims, wherein the pump/motor unit is connected to a corresponding pair of the associated non-driven wheels disposed on opposite sides of the trailer via a differential.

26. A regenerative energy management system according to claim 25, wherein a main pinion shaft for the differential forms the drive shaft of the pump/motor unit.

27. A regenerative energy management system according to claim 26, wherein two or more pairs of wheels are connected to the same pump/motor unit via respective differentials and a common pinion shaft, whereby four or more of the associated wheels of the trailer are regulated by a single pump/motor unit.

28. A regenerative energy management system according to claim 27, wherein the pairs of wheels, the differentials, the common pinion shaft and the pump/motor unit are incorporated into a discretely detachable bogie assembly.

29. A regenerative energy management system according to claim 28, wherein the differentials have limited slip or locking capability, thereby permitting torque bias in the event of one wheel losing traction.

30. A regenerative energy management system according to any one of claims 27 to 29, wherein additional pump/motor units are disposed along the common pinion shaft.

31. A regenerative energy management system according to any one of the preceding claims, further including a control system configured to regulate braking and driving torques applied to the associated wheel in the respective braking and driving modes, in response to braking and driving control inputs to the prime mover.

32. A regenerative energy management system according to any one of the preceding claims, being arranged to provide effective braking functionality for the compound vehicle in the braking mode, substantially independently of a conventional friction braking system.

33. A regenerative energy management system according to any one of the preceding claims, being arranged to provide at least a limited degree of driving functionality for the compound vehicle in the driving mode, substantially independently of the drive train of the prime mover.

34. A regenerative energy management system according to claim 32 or claim 33, wherein selected wheels constituting a major proportion of wheels in the trailer are coupled to the regenerative energy management system.

35. A regenerative energy management system according to any one of the preceding claims, being supplemented by a further regenerative energy management system connected directly to the drive line of the prime mover.